

I CLAIM:

1. A material drying apparatus for continuous operation to substantially evaporate the liquid content of a sludge, the apparatus comprising:

- a first stage operating at ambient pressure for heating the sludge;
- a second stage operating with partial vacuum for receiving heated sludge

from the first stage for further heating and for drying the sludge by evaporation of substantially all liquid therefrom to leave a dry particulate material; and

a cyclonic stage operating with a partial vacuum for applying sufficient centrifugal force to the dry particulate material to render this material substantially odorless.

2. The apparatus of claim 1 comprising a venturi nozzle for accelerating the dry particulate material prior to entry into the cyclonic stage.

3. The apparatus of claim 2 comprising a vacuum system to provide a partial vacuum in the second stage and the cyclonic stage, and to remove evaporated liquid from the apparatus.

4. The apparatus of claim 1 comprising steam heated jackets for heating the first and second stages.

5. The apparatus of claim 1 wherein the first stage comprises a cylindrical housing defining a longitudinal axis, a hollow shaft coaxial with the housing and extending entirely through the housing, and conveyor paddles mounted on the hollow shaft and helically inclined relative to the axis to convey, upon rotation of the hollow shaft, sludge from an input end of the cylindrical housing to an outlet end thereof while being heated.

6. The apparatus of claim 5 wherein the paddles terminate at their radially outer ends sufficiently proximate the cylindrical housing to scrape sludge from the housing during rotation of the paddles about the axis by the hollow shaft.

7. The apparatus of claim 4 wherein the paddles are mounted on the hollow shaft by tubes the interiors of which are open to the interior of the hollow shaft whereby steam introduced into the hollow shaft will enter the tubes to provide a heat source for the sludge.

8. The apparatus of claim 7 comprising steam heated jackets for heating sludge in the first stage.

9. The apparatus of claim 1 comprising a rotary transfer lock disposed between an outlet for the heated sludge from the first stage and the inlet for the heated sludge into the second stage, the transfer lock comprising a cylindrical chamber closed at its ends and housing a finned rotor having a plurality of fins cooperating with the cylindrical chamber to substantially prevent loss of the partial vacuum from the second stage while, upon rotation of the finned rotor, the heated sludge from the first stage is metered through the transfer lock for onward transmission to the second stage.

10. The apparatus of claim 9 wherein the finned rotor is hollow and is provided with openings to allow air introduced into the rotor to pass into the heated sludge being metered through the transfer lock in order to prevent clogging of the sludge in the rotary transfer lock.

11. The apparatus of claim 9 comprising a shredder disposed between the rotary transfer lock and the inlet for the heated sludge into the second stage, the shredder serving to break the heated sludge into small pieces and particles.

12. The apparatus of claim 1 wherein the second stage comprises a cylindrical housing defining a longitudinal axis, a hollow shaft coaxial with said housing and a plurality of tined projections mounted on the shaft for rotation with the shaft to agitate particles and break up small pieces of the sludge entering the second stage.

13. The apparatus of claim 12 wherein the tined projections terminate closely adjacent the housing with each projection having a plurality of tines and with the housing supporting blocks which cooperate with the tines upon rotation thereof to remove material from between the tines.

14. The apparatus of claim 12 comprising a steam heatable jacket surrounding the cylindrical housing to heat the sludge in the second stage.

15. The apparatus of claim 14 wherein the tined projections are mounted on the hollow shaft by tubes the interiors of which are open to the interior of the

hollow shaft to receive steam passed through the hollow shaft to provide additional heating of the sludge.

16. The apparatus of claim 1 wherein dried particulate material from the second stage is drawn into a cyclone by a vacuum pump connected to the cyclone to provide the partial vacuum in the cyclone and second stage, the material being drawn into the cyclone by way of a venturi to accelerate the particles for entry tangentially into the cyclone whereby centrifugal force generated by passage of the dried particles in the cyclone renders the dried particles substantially odorless.

17. The apparatus of claim 16 comprising a rotary transfer lock located to provide an outlet for particles from the cyclone and to substantially prevent loss of the partial vacuum from the second stage and the cyclone.

18. The apparatus of claim 5 wherein shaft scraping paddles are mounted on the cylindrical housing between adjacent pairs of the conveyor paddles.

19. The apparatus of claim 1 wherein the sludge is heated in the first stage to at least 200°F, the temperature of the heated sludge entering the second stage is at least 200°F and the partial vacuum in the second stage in the cyclone is about 20 inches of mercury below atmospheric pressure.

20. A method of drying sludge to produce a benign particulate material comprising the steps of :

- a) heating the sludge at ambient pressure to a temperature of at least 200°F while being continuously conveyed through a first stage of an apparatus;
- b) heating and drying the previously heated sludge under a partial vacuum in a second stage of the apparatus;
- c) substantially preventing loss of the partial vacuum from the second stage at a location between the first and second stages;
- d) shredding the heated sludge to reduce the heated sludge to small pieces and particles prior to entry into the second stage;
- e) agitating the small pieces and particles in the second stage to break up the small pieces therein; and
- f) subjecting the particles dried in the second stage to a centrifugal force sufficient to render the particulate product substantially odorless.